We claim:

1   1.   A method for use in a system adapted to transmit at least

2   four series of transmit sequences over at least four transmit antennas,

3   the method comprising the step of:

4   space-time coding at least two pairs of symbol sub-streams, each of

5   the pairs of symbol streams being space-time coded to form a respective

6   pair of the transmit-sequence chains, the space-time coding being such

7   that at least one of the formed pairs of the transmit-sequence chains is a

8   function of symbols of the respective pair of symbol sub-streams and not

9   a function of the symbols of the other pairs of the symbol sub-streams.

        2.   The invention of claim 1, wherein

1   each transmit sequence has a duration of four symbol periods;

2   each transmit sequence of a particular transmit-sequence chains is

3   a function of 1) a symbol of one of the symbol sub-streams of the

4   respective symbol-sub-stream pair and 2) a complex conjugate of a

5   symbol of the other symbol sub-stream of the respective symbol-sub-

6   stream pair; and

7   portions of the at least four transmit-sequence chains are

8

9   representable by a matrix where:

10   each row of the matrix represents one transmit sequence of a

11   respective different one of the transmit-sequence chains, and

12   each column of the matrix represents one symbol period.

1   3.   The invention of claim 2, wherein the matrix is orthogonal.

1   4.   The invention of claim 1, wherein portions of the at least four

2   transmit-sequence chains are representable by a matrix where:

3   each row of the matrix represents one transmit sequence of a

4   respective different one of the transmit-sequence chains;

5   each column of the matrix represents one symbol period; and

6   the matrix is $\begin{bmatrix} b_1 & b_1 & -b_2^* & -b_2^* \\ b_2 & b_2 & b_1^* & b_1^* \\ b_3 & -b_3 & -b_4^* & b_4^* \\ b_4 & -b_4 & b_3^* & -b_3^* \end{bmatrix}$,

7   where:

8   b_1 and b_2 are symbols of first and second symbol sub-streams,

9   respectively, of one of the symbol-sub-stream pairs,

10   b_3 and b_4 are symbols of first and second symbol sub-streams,

11   respectively, of another of the symbol-sub-stream pairs, and

12   b_1^*, b_2^*, b_3^*, and b_4^* are complex conjugates of b_1, b_2, b_3, and b_4,

13   respectively.

5.   The invention of claim 1, wherein portions of the at least four

2   transmit-sequence chains are representable by a matrix where:

3   each row of the matrix represents one transmit sequence of a

4   respective different one of the transmit-sequence chains;

5   each column of the matrix represents one symbol period; and

6   the matrix is $\begin{bmatrix} b_1 & -b_2^* & 0 & 0 \\ b_2 & b_1^* & 0 & 0 \\ 0 & 0 & b_3 & -b_4^* \\ 0 & 0 & b_4 & b_3^* \end{bmatrix}$,

7   where:

8   b_1 and b_2 are symbols of first and second symbol sub-streams,

9   respectively, of one of the symbol-sub-stream pairs,

10   b_3 and b_4 are symbols of first and second symbol sub-streams,

11   respectively, of another of the symbol-sub-stream pairs, and

12 b_1^*, b_2^*, b_3^*, and b_4^* are complex conjugates of b_1, b_2, b_3, and b_4,

13 respectively.

1   6.   The invention of claim 1, wherein the space-time coding step

2 comprises the steps of:

3   space-time coding a first pair of symbol sub-streams to form a first

4 pair of transmit-sequence chains, the first pair of transmit-sequence

5 chains being a function of the symbols of the first symbol-sub-stream

6 pair and not a function of the symbols of a second symbol-sub-stream

7 pair; and

8   space-time coding the second pair of symbol sub-streams to form a

9 second of transmit-sequence chains, the second pair of transmit-

10 sequence chains being a function of the symbols of the second symbol-

11 sub-stream pair and not a function of the symbols of the first symbol-

12 sub-stream pair.

1   7.   The invention of claim 1, further comprising the step of

2 transmitting the at least four transmit-sequence chains on a respective

3 one of the transmit antennas.

1   8.   The invention of claim 1, further comprising the step of

2 spreading at least a plurality of symbols of the transmit-sequence chains

3 using a spreading code.

1   9.   The invention of claim 1, further comprising the steps of:

2   channel coding each of at least four data sub-streams using a

3 channel code; and

4   mapping each of the channel-coded primitive data stream into

5 symbol-space to produce a respective one of the symbol sub-streams.

1 10. A transmitter adapted to transmit at least four symbol sub-
2 streams, the transmitter comprising:

3   a space-time encoder adapted to space-time code at least two pairs
4 of symbol sub-streams, each of the pairs of symbol streams being space-
5 time coded to form a respective pair of the transmit-sequence chains, the
6 space-time coding being such that at least one of the formed pairs of the
7 transmit-sequence chains is a function of symbols of the respective pair
8 of symbol sub-streams and not a function of the symbols of the other
9 pairs of the symbol sub-streams; and

10   at least four transmit antennas, each having an input for receiving
11 at least one of the at least four transmit-sequence chains, the input
12 coupled to an output of the space-time encoder.

1 11. The invention of claim 10, wherein
2   each transmit sequence has a duration of four symbol periods;

3   each transmit sequence of a particular transmit-sequence chains is
4 a function of 1) a symbol of one of the symbol sub-streams of the
5 respective symbol-sub-stream pair and 2) a complex conjugate of a
6 symbol of the other symbol sub-stream of the respective symbol-sub-
7 stream pair; and

8   portions of the at least four transmit-sequence chains are
9 representable by a matrix where:

10   each row of the matrix represents one transmit sequence of a
11 respective different one of the transmit-sequence chains, and

12   each column of the matrix represents one symbol period.

1 12. The invention of claim 11, wherein the matrix is orthogonal.

1   13.   The invention of claim 10, wherein portions of the at least

2   four transmit-sequence chains are representable by a matrix where:

3   each row of the matrix represents one transmit sequence of a

4   respective different one of the transmit-sequence chains;

5   each column of the matrix represents one symbol period; and

6   the matrix is one of the matrices of the set of matrices consisting

7   of:

$$
\begin{bmatrix} b_1 & b_1 & -b_2^* & -b_2^* \\ b_2 & b_2 & b_1^* & b_1^* \\ b_3 & -b_3 & -b_4^* & b_4^* \\ b_4 & -b_4 & b_3^* & -b_3^* \end{bmatrix} \text{ and } \begin{bmatrix} b_1 & -b_2^* & 0 & 0 \\ b_2 & b_1^* & 0 & 0 \\ 0 & 0 & b_3 & -b_4^* \\ 0 & 0 & b_4 & b_3^* \end{bmatrix},
$$

9   where:

10   b_1 and b_2 are symbols of first and second symbol sub-streams,

11   respectively, of one of the symbol-sub-stream pairs,

12   b_3 and b_4 are symbols of first and second symbol sub-streams,

13   respectively, of another of the symbol-sub-stream pairs, and

14   b_1^*, b_2^*, b_3^*, and b_4^* are complex conjugates of b_1, b_2, b_3, and b_4,

15   respectively.

1   14.   The invention of claim 10, wherein the space-time encoder is

2   adapted to spread at least a plurality of symbols of the transmit-

3   sequence chains using a spreading code.

1   15.   The invention of claim 10, wherein the transmitter further

2   comprises:

3   an input; and

4   at least one channel encoder being interposed between the input

5   and the space-time encoder, the channel encoder adapted being to

6   channel code a data sub-stream using a channel code.

1   16.   The invention of claim 15, wherein the transmitter further

2   comprises at least one mapper, the mapper being interposed between the

3   channel encoder and the space-time encoder, the mapper being adapted

4   to map the channel coded data sub-stream into symbol-space to produce

5   a respective one of the symbol sub-streams.

1   17.   A base station of a wireless communication system, the base

2   station comprising the transmitter of claim 10.

1   18.   A mobile terminal comprising the transmitter of claim 10.

1   19.   The invention of claim 10, further comprising a plurality of

2   radio frequency units, each having an input coupled to a respective

3   output of the space-time encoder, each radio frequency unit adapted to

4   convert a respective transmit sequence series from baseband to a radio

5   frequency modulated signal.

1   20.   A receiver comprising:

2   at least one receive antenna; and

3   a matrix multiplier for multiplying a matrix with received symbol

4   sub-streams of a signal received by the receive antenna, the matrix

5   having at least two pairs of consecutive rows, each such pair being a

6   function of channel characteristics of at least two channels that

7   terminate on the receive antenna but not of channel characteristics of

8   other channels that terminate on the receive antenna, and the matrix

9   being orthogonal.

1   21.   The invention of claim 20, wherein the matrix is $\mathbf{H}^\dagger$, which

2   comprises one of the matrices of the set of matrices consisting of:

3
$$\begin{bmatrix} h_1^* & h_2^* & h_2 & h_2 \\ h_2^* & h_2^* & -h_1^* & -h_1 \\ h_3^* & -h_3^* & h_4 & -h_4 \\ h_4^* & -h_4^* & -h_3 & h_3 \end{bmatrix} \text{ and } \begin{bmatrix} h_1^* & h_2 & 0 & 0 \\ -h_2^* & h_1 & 0 & 0 \\ 0 & 0 & h_3^* & h_4 \\ 0 & 0 & -h_4^* & h_3 \end{bmatrix},$$

4   where h_1, h_2, h_3, and h_4 are the complex channel characteristics of the

5   channels between a 1st, 2nd, 3rd, and 4th channel encoder, respectively

6   and the receive antenna.

1   22.   The invention of claim 21, wherein the channels are flat-faded

2   channels.